

Description

MOTOR PRODUCTION LINE AND METHOD OF CONTROLLING THE SAME

Technical Field

The present invention relates to a production line suited for the production of motors of many kinds in small quantities and to a control method therefor.

Background Art

In the production of a motor, a rotor and a stator for constituting the motor are separately fabricated and are finally combined together to assemble the motor. Further, both the rotor and the stator are using, as cores, a rotor core and a stator core obtained by laminating many electromagnetic steel plates that have been punched into desired shapes. These rotor core and stator core are formed by using a press apparatus in which an elongated electromagnetic steel plate is fed to pass through a plurality of press steps.

Referring to Fig. 9, a motor production line 9 has heretofore been constituted to be suited for a mass production, including a dedicated press plant 91 where a large press apparatus is installed to efficiently produce the rotor cores and the stator cores. The press plant 91 is furnished with a press apparatus which is capable of executing the punching at a rate as high as, for example, 100 SPM or higher.

Near the press plant 91, there are provided a stock warehouse 92 for storing rotor cores and stator cores produced in the press plant 91, and a plurality of assembly plants 93, 94, 95, --- where the rotor cores and stator cores are assembled.

The press plant 91 produces the rotor cores and the stator cores of the same specification in large quantities for a predetermined period of time, and the rotor cores and the stator cores are conveyed from the press plant 91 to the stock warehouse 92 and are stored therein. Thereafter, the rotor cores and the stator cores of another type are produced in large quantities, and are conveyed from the press plant 91 to the stock warehouse 92 and are stocked therein.

In the plurality of assembly plants 93, 94 and 95, on the other hand, the rotor cores and the stator cores for motors to be produced are carried from the stock warehouse 92, and are assembled.

A large press apparatus installed in a conventional press plant may be the one disclosed in, for example, JP-A-2002-136065.

However, the conventional motor production line is accompanied by problems as described below.

That is, the production of many kinds of motors in small quantities through the above conventional motor production line inevitably results in a great increase in both the quantity and kinds of the rotor cores and the stator cores that are to be stored, and the warehouse requires a large space for storage.

Besides, the rotor cores and the stator cores are stored for extended periods of time causing the qualities such as insulation properties to be deteriorated due to the occurrence of rust and adhesion of foreign matter.

Further, while being stored for extended periods of time in the stock warehouse, the chances increase for rearrangement and mounting, increasing the probability of causing defects such as deformation, etc. To suppress the deterioration of quality, further, a countermeasure must be taken, such as rust-prevention treatment, accommodating the cores in the stock boxes, etc., driving up the cost of production due to management cost.

Moreover, the rotor cores and the stator cores are stored for extended periods of time as described above and, hence, a lead time becomes very long from the start of production until the finish, arousing various harmful influences.

Disclosure of the Invention

This invention was accomplished in view of the above-mentioned problems, and provides a motor production line which is best suited for the production of many kinds of motors in small quantities while decreasing the lead time and a production method thereof.

A first aspect of the invention is concerned with a motor production line for producing, at least, a stator for

constituting a motor, comprising:

a press apparatus for forming a stator core by feeding a long steel plate to pass through a plurality of times of press work, and laminating a plurality of pieces of steel plates; and

a stator assembling apparatus for assembling a stator by passing the stator core through a plurality of production steps; wherein,

a stator core conveyer apparatus is arranged between the stator assembling apparatus and the press apparatus to successively and directly convey the stator cores formed by the press apparatus to the stator assembling apparatus.

As described above, the motor production line of the invention includes the press apparatus and the stator assembling apparatus with the stator core conveyer apparatus arranged therebetween. In other words, the press apparatus and the stator assembling apparatus are coupled together in an organic manner through the stator core conveyer apparatus to thereby constitute a single continuous line as a whole.

As described above, the stator core conveyer apparatus is so constituted as to convey the stator cores formed by the press apparatus to the stator assembling apparatus successively and directly (the stator cores, however, may be indirectly conveyed while arbitrarily changing the order, as a matter of course). Unlike the prior art, therefore, the stator cores

need not at all be stored as stocks. This precludes the probability of a decrease in the quality of the stator cores and, hence, suppresses the percent defective, that were the problems inherent in the prior art. Besides, neither the stock warehouse nor the preservation cost is required, and the cost of production can be lowered.

Further, the stator cores produced by the press apparatus are successively conveyed to the stator assembling apparatus, and are successively assembled into stators. Therefore, the stators are produced in a minimum lead time. This makes it possible to shorten the lead time for finishing the whole motor as compared to the prior art.

The press apparatus needs have a capability that meets the production capability of only one type of stator assembling apparatus. Unlike the prior art, therefore, there is no need of introducing a large, high-speed and expensive press apparatus, and the cost related to the facility can be greatly decreased. Instead, the similarly constituted motor production lines can be provided in a plural number for producing motors of different specifications. Therefore, the motors of many kinds can be ideally produced in small quantities.

A second aspect of the invention is concerned with a method of controlling the motor production line which includes a press apparatus for forming a rotor core and a stator core by feeding a long steel plate to pass through a plurality of times of press

work, and laminating a plurality of pieces of steel plates, a rotor assembling apparatus for assembling a rotor by passing the rotor core through a plurality of production steps, and a stator assembling apparatus for assembling a stator by passing the stator core through a plurality of production steps, the method of controlling the motor production line comprising the steps of:

accepting a production instruction inclusive of data related to the number N of motors to be produced;

starting the operations of the press apparatus, the rotor assembling apparatus and the stator assembling apparatus after having accepted the production instruction; and

halting the operation of the press apparatus depending upon the production conditions in the rotor assembling apparatus and the stator assembling apparatus; wherein

if the number of the finished rotors assembled by the rotor assembling apparatus is denoted by R_1 , the number of the half assembled rotors by R_2 , the number of the finished stators assembled by the stator assembling apparatus by S_1 and the number of the half assembled stators by S_2 , then, the press halting step halts the operation of the press apparatus when $N \leq R_1 + R_2$ and $N \leq S_1 + S_2$.

A variety of methods can be employed for controlling the motor production line, particularly, having the press halting step as in the above second aspect of the invention.

That is, in the press halting step, it is judged whether the press apparatus be halted depending upon the production conditions of the rotor assembling apparatus and the stator assembling apparatus, i.e., depending upon whether a total number of the finished units and the number of the half finished units has reached a number N of the units that are to be produced. The press apparatus continues to operate until the total number reaches N. When the total number reaches N for either the rotors or the stators, the operation of the press apparatus is discontinued.

In the above motor production line, therefore, the production is executed at one time from the formation of the rotor cores and stator cores through up to the assembly of the rotors and stators only when it is necessary and in only a required quantity. The lead time is minimized from the start of production until the finishing and, besides, no wasteful stock needs be stored.

As described above, the control method of the present invention enables the motor production line to exhibit its excellent characteristics to a sufficient degree.

Brief Description of the Drawings

Fig. 1 is a view illustrating the constitution of a motor production line according to an embodiment;

Fig. 2a is a plan view of a rotor core formed by a press

apparatus according to the embodiment;

Fig. 2b is a side view of the rotor core formed by the press apparatus according to the embodiment;

Fig. 3a is a plan view of a stator core formed by a press apparatus according to the embodiment;

Fig. 3b is a side view of the stator core formed by the press apparatus according to the embodiment;

Fig. 4a is a plan view of a rotor fabricated by a rotor assembling apparatus according to the embodiment;

Fig. 4b is a plan view of the rotor fabricated by the rotor assembling apparatus according to the embodiment;

Fig. 5a is a plan view of a stator fabricated by a stator assembling apparatus according to the embodiment;

Fig. 5b is a side view of the stator fabricated by the stator assembling apparatus according to the embodiment;

Fig. 6 is a flowchart illustrating a method of controlling the motor production line according to the embodiment;

Fig. 7 is a diagram illustrating lead times in a comparative example;

Fig. 8 is a diagram illustrating lead times according to the embodiment; and

Fig. 9 is a diagram illustrating a layout of a motor production plant according to a prior art.

Best Mode for Carrying Out the Invention

In the above one aspect of the invention, it is desired that the press apparatus is so constituted as to form the stator core as well as to form a rotor core by laminating a plurality of pieces of steel plates, and that the motor production line includes a rotor assembling apparatus for assembling a rotor by passing the rotor core through a plurality of production steps, and a rotor core conveyer apparatus arranged between the rotor assembling apparatus and the press apparatus to successively and directly convey the rotor formed by the press apparatus to the rotor assembling apparatus.

In this case, the press apparatus and the rotor core assembling apparatus are organically coupled together in addition to organically coupling the press apparatus and the stator assembling apparatus together. This makes it possible to further enhance the above excellent effect.

That is, the rotor cores and the stator cores produced by the press apparatus are successively conveyed in parallel to the rotor assembling apparatus and to the stator assembling apparatus, and are successively assembled into rotors and stators. Subsequently, therefore, the rotors and the stators are combined together to obtain finished products in a minimum lead time. This almost removes harmful influences caused by a long lead time.

It is further desired that the motor production line

includes a centralized control unit for exclusively controlling the press apparatus, stator assembling apparatus, rotor assembling apparatus, stator core conveyer apparatus and rotor core conveyer apparatus.

In this case, the centralized control unit exclusively manages and controls the press apparatus, stator assembling apparatus, rotor assembling apparatus, stator core conveyer apparatus and rotor core conveyer apparatus maintaining smooth linkage to the apparatuses making it possible to accomplish an efficient production.

As the rotor core conveyer apparatus and the stator core conveyer apparatus, there can be employed the conveyer apparatuses of various constitutions, such as a roller conveyer, a belt conveyer, a lifter, a loader, a robot, or a combination thereof.

It is further desired that the rotor core conveyer apparatus and the stator core conveyer apparatus are constituted as a common conveyer apparatus. That is, the rotor core conveyer apparatus and the stator core conveyer apparatus may be separately arranged as dedicated facilities. It is, however, desired that a single conveyer apparatus is so constituted as to work as the rotor conveyer apparatus and as the stator core conveyer apparatus. Every time when the rotor core and the stator core are formed by the press apparatus, further they may be alternately conveyed to the rotor assembling apparatus

and to the stator assembling apparatus. In this case, the cost of facility can be decreased, and plant space can be reduced.

It is further desired that a rotor delivery passage for delivering the rotor assembled by the rotor assembling apparatus and a stator delivery passage for delivering the stator assembled by the stator assembling apparatus, meet together to constitute a common delivery passage, and that every pair of the rotor and the stator for constituting a motor are delivered simultaneously or consecutively in the back-and-forth direction.

In this case as described above, the pair of rotor and stator are delivered from a common delivery passage simultaneously or consecutively in the back-and-forth direction. In a subsequent step of combining the rotor and the stator into one, therefore, there is no need of conveying again the rotor and the stator that are to be combined together. Therefore, the steps of producing motors can be carried out very ideally. Besides, the rotor and the stator to be combined together become inevitably those in the same lot. Accordingly, dimensional errors occur little, and motors of higher qualities can be produced.

Embodiment

The motor production line according to the embodiment of the invention will now be described with reference to Figs.

1 to 8.

Referring to Fig. 1, the motor production line 1 is the one for producing a rotor 7 (Fig. 4) and a stator 8 (Fig. 5) simultaneously and in parallel to constitute a motor.

As shown in Fig. 1, the motor production line 1 includes a press apparatus 10 for forming a rotor core 70 (Fig. 2) and a stator core 80 (Fig. 3) by feeding a long steel plate to subject it to the press work of a plural number of times and by laminating a plurality of pieces of steel plates, a rotor assembling apparatus 3 for assembling a rotor 7 by passing the rotor core 70 through a plurality of production steps, and a stator assembling unit 4 for assembling a stator 8 by passing the stator core 80 through a plurality of production steps.

Between the rotor assembling apparatus 3 and the press apparatus 10, there is arranged a rotor core conveyer apparatus 21 for successively and directly conveying the rotor cores 70 formed by the press apparatus 10 to the rotor assembling apparatus. Between the stator assembling apparatus 4 and the press apparatus 10, there is arranged a stator core conveying apparatus 22 for successively and directly conveying the stator cores 80 formed by the press apparatus 10 to the stator assembling apparatus.

This will now be described in detail.

Figs. 2 to 5 illustrate the rotor core 70 and the stator core 80 formed by the press apparatus 10 of this embodiment,

and the rotor 7 and the stator 8 fabricated by using them.

Referring to Fig. 2, the rotor core 70 is constituted by laminating many steel plates 700 that are punched for forming the rotor core, has, at the central portion thereof, shaft holes 701 in which will be inserted a rotary shaft 71 (Fig. 4), and has, near the outer periphery thereof, magnet arrangement holes 702 for mounting magnets. The rotor core 70 is subjected to the production steps in the rotor assembling apparatus 3 and is assembled into the rotor 7 as shown in Fig. 4. The rotor 7 has a rotary shaft 71 at the center of the rotor core 70, contains magnets therein, and has rotor core-holding plates 72 at both end surfaces of the rotor core 70.

Referring to Fig. 3, the stator core 80 is constituted by laminating many steel plates 800 that are punched for forming the stator core, has, at the central portion thereof, through holes 802, and has slots 801 opened in the inner peripheral surface thereof. The stator core 80 is subjected to the production steps in the stator assembling apparatus 4 and is assembled into the stator 8 as shown in Fig. 5. The stator 8 has a group of coils 81 inserted in the slots 801 and secured by using a varnish, and has a plurality of coil neutral points 82 to 84 formed in a protruding manner.

Next, described below are the constitutions of the apparatuses in the motor production line 1 of this embodiment.

Referring to Fig. 1, the press apparatus 10 according

to this embodiment includes a blank feeding portion 11 for setting a steel plate in the form of a coil that is a blank material for the rotor cores 70 and the stator cores 80, a forward-feed press portion 12 arranged downstream thereof and having a plurality of punching stages, and a scrap pallet portion 13 for recovering scraps such as punched scraps.

The forward-feed press portion 12 is facing the inlet side of the rotor assembling apparatus 3 and the stator assembling apparatus 4, and is provided with a rotor core conveyer apparatus 21 and a stator core conveyer apparatus 22.

The rotor core conveyer apparatus 21 and the stator core conveyer apparatus 22 of this embodiment are both constituted chiefly by roller conveyers. The rotor core conveyer apparatus 21 is so constituted as to throw the rotor core 70 into the inlet side of the rotor assembling apparatus 3 every time when the rotor core 70 is formed by the press apparatus 10. Similarly, the stator core conveyer apparatus 22 is so constituted as to throw the stator core 80 into the inlet side of the stator assembling apparatus 4 every time when the stator core 80 is formed by the press apparatus 10.

The rotor core conveyer apparatus 21 and the stator core conveyer apparatus 22 can be replaced by conveyer apparatuses of various constitutions other than the roller conveyers. Further, the rotor core conveyer apparatus 21 and the stator core conveyer apparatus 22 may be constituted by a common

conveyer apparatus.

On the inlet side of the rotor assembling apparatus 3, there is provided a lifter 31 which hoists the rotor core 70 received from the rotor core conveyer apparatus 21 to a predetermined height to hand it over to the carrier line 30.

The carrier line 30 is so constituted as to carry the rotor core 70 that is thrown in toward the outlet side passing through the production steps, successively.

As shown in Fig. 1, the rotor assembling apparatus 3 includes a magnet incorporating portion 32 for incorporating the magnets into the rotor core, an adhesive-curing portion 33 for solidifying the magnets with an adhesive, nut-fastening caulking portion 34 for securing the rotor core and the shaft together by nuts, a resolver press-inserting portion 35 for press-inserting the resolver rotor for detecting the magnetic pole position into the shaft, and a D/B measurement/correction portion 36 for measuring and correcting the rotational balance.

On the inlet side of the stator assembling apparatus 4, further, there is provided a lifter 41 for hoisting the stator core 80 received from the stator core conveyer apparatus 22 to a predetermined height to hand it over to a carrier line 40.

The carrier line 40 is so constituted as to carry the stator core 80 that is thrown in toward the outlet side passing through the production steps, successively.

As shown in Fig. 1, the stator assembling apparatus 4 includes a throttle cell insertion portion 42 for inserting an insulation paper in the slots 801 of the stator core 80, a coil mounting portion 43 for mounting a coil formed by a coil-forming portion 431 and an inter-phase insulation paper on the stator core 80, and an insulation sleeve mounting portion 44 for insulating the lead wires. On the downstream thereof, there are provided a neutral point fusing portion 45 for joining the neutral points of the coil mounted on the stator core 80, a C/E forming portion 46 for trimming coil end portions in a desired shape, a lacing portion 47 for bundling a plurality of coil end portions, a power cable fusing portion 48 for joining the coil and the electric contacts, a varnish-impregnating portion 491 for impregnating the coil with a varnish, a varnish-curing portion 492 for curing the impregnated varnish, and a winding measuring portion 493 for measuring electric characteristics.

The rotor delivery passage for delivering the rotor 7 assembled by the rotor-assembling apparatus 3 and the stator delivery passage for delivering the stator 8 assembled by the stator assembling apparatus 4, meet together to constitute a common delivery passage 50.

Near the common delivery passage 50, there is provided a laser engraving portion 37 for effecting the printing on the finished rotor 7 and the stator 8 by using a laser beam.

Each pair of the rotor 7 and the stator 8 on which necessary items are printed are delivered in the back-and-forth direction every after the fabrication of a motor.

Further, the motor production line 1 of this embodiment includes the centralized control unit (not shown) capable of exclusively controlling the press apparatus 10, stator assembling apparatus 4, rotor assembling apparatus 3, stator core conveyer apparatus 22 and rotor core conveyer apparatus 21. The control operation is exclusively accomplished by the centralized control unit.

Briefly described below is a method of controlling the thus constituted motor production line 1.

The motor production line 1 of this embodiment has a control apparatus (not shown) for receiving an instruction from a production management computer (not shown) at a superior position, which controls the operation of the press apparatus 10, operation of the rotor assembling apparatus 3 and operation of the stator assembling apparatus 4.

Fig. 6 is a flowchart simply illustrating how to control the motor production line 1.

A first step is for accepting a production instruction inclusive of data related to the number N of motors to be produced (ST1).

Next, in response to the production instruction, the control apparatus starts operating the press apparatus 10, rotor

assembling apparatus 3 and stator assembling apparatus 4 (ST2). At this moment, the rotor core 70 and the stator core 80 have not yet been fed to the rotor assembling apparatus 3 and to the stator assembling apparatus 4. Therefore, the assembling operation has not yet been started. After a while, as the rotor core 70 and the stator core 80 are fed to the rotor assembling apparatus 3 and to the stator assembling apparatus 4, the steps of production start working in these apparatuses.

Then, in parallel with the formation of the rotor core 70 and the stator core 80 by the press apparatus 10, the rotor 8 is fabricated by the rotor assembling apparatus 3 and the stator 7 is fabricated by the stator assembling apparatus 4 at the same time.

Next, the control apparatus executes preparatory steps (ST3 to ST5) for executing press-halting step (ST6) to halt the operation of the press apparatus 10.

That is, step ST3 continues to collect the data related to a number R_1 of the finished rotors representing the accumulated number of the rotors 7 completely assembled by the rotor assembling apparatus 3, a number R_2 of the half assembled rotors representing the number of the rotor cores half assembled by the rotor assembling apparatus 3, as well as a number S_1 of the finished stators representing the accumulated number of the stators 8 completely assembled by the stator assembling apparatus 4 and a number S_2 of the half assembled stators

representing the number of the stator cores half assembled by the stator assembling apparatus 4.

Next, at step ST4, the production conditions of the rotors are judged, first. Namely, it is judged whether the total number of R_1 and R_2 is greater than N . When $R_1 + R_2$ is greater than N , the routine proceeds to next step ST5.

At step ST5, the production conditions of the stators are judged. Namely, it is judged whether the total number of S_1 and S_2 is greater than N . Only when $S_1 + S_2$ is greater than N , the routine proceeds to next step ST6.

At step ST6, the operation of the press apparatus 10 is discontinued as described above.

The above control method makes it possible to draw excellent characteristics of the motor production line 1 of this embodiment to a sufficient degree, and to execute the production at one time from the formation of the rotor cores and stator cores through up to the assembly of the rotors and stators only when it is necessary and in only a required quantity. The lead time is minimized from the start of production until the finishing and, besides, no wasteful stock needs be stored.

Next, the effect for shortening the lead time will be briefly described with reference to Figs. 7 and 8.

Fig. 7 illustrates a comparative example in the case of a press plant 91 (Fig. 9) equipped with a conventional large press apparatus for mass production, and Fig. 8 illustrates

an example of the case of employing the motor production line 1 of the embodiment.

In both of these drawings, the abscissas represent the time, the uppermost stage thereof representing a timing at which the production instruction is issued, the middle stage thereof representing the core production cycle times (Cy1, Cy3) for forming a rotor core and a stator core of a motor by the press apparatus, and the lowermost stage thereof representing the motor production cycle times (Cy2, Cy4) for assembling the rotor and the stator.

As will be learned from these two drawings, the core production cycle time Cy1 according to the prior art is very shorter than the core production cycle time Cy3 of this embodiment. In both the prior art and this embodiment, however, the motor production cycle times Cy2 and Cy4 are nearly of the same lengths.

Here, what draws attention is that in the prior art as illustrated in Fig. 9, the rotor cores and the stator cores are produced in the press plant 91 highly efficiently and in large quantities, and are successively conveyed to the stock warehouse 92. In the assembling plant 93, on the other hand, the rotor cores and the stator cores are carried after having confirmed that the rotor cores and stator cores of predetermined quantities have been stored and, then, the production starts. According to the prior art, therefore, the lead time 1 becomes

very long including production of many number of rotor cores and stator cores, stock-storing period and carrying time.

In this embodiment, on the other hand, the lead time 2 includes only a core production cycle time Cy3, a motor production cycle time Cy4, as well as times for handing the rotor core and the stator core over to the rotor assembling apparatus 3 and to the stator assembling apparatus 4 by using the rotor core conveyer apparatus 21 and the stator core conveyer apparatus 22. Therefore, the lead time 2 is very shorter than the lead time 1 of the prior art.

According to the motor production line 1 of this embodiment as described above, the press apparatus 10, rotor assembling apparatus 3 and stator assembling apparatus 4 are coupled together through the rotor core conveyer apparatus 21 and the stator core conveyer apparatus 22 in an organic manner to constitute a single continuous line as a whole.

Unlike the prior art, therefore, the rotor cores 70 and the stator cores 80 need not at all be stored as stocks. This precludes the probability of a decrease in the quality of the rotor cores and the stator cores and, hence, suppresses the percent defective, that were the problems inherent in the prior art. Besides, neither the stock warehouse nor the preservation cost is required, and the cost of production can be lowered.

Further, the rotor cores 70 and the stator cores 80 produced by the press apparatus 10 are successively conveyed

in parallel to the rotor assembling apparatus 3 and to the stator assembling apparatus 4, and are successively assembled into rotors 7 and stators 8. Subsequently, therefore, the rotors 7 and the stators 8 are combined together to obtain finished products in a minimum lead time. This almost removes harmful influences caused by a long lead time.

Further, the press apparatus 10 needs have a capability that meets the production capabilities of only one type of rotor assembling apparatus 3 and only one type of stator assembling apparatus 4. Unlike the prior art, therefore, there is no need of introducing a large, high-speed and expensive press apparatus, and the cost related to the facility can be greatly decreased. Instead, the similarly constituted motor production lines can be provided in a plural number for producing motors of different specifications. Therefore, the motors of many kinds can be ideally produced in small quantities.